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ANNUAL REPORT

Decision Aid Evaluation Program

**Arthur I. Siegel
Edward G. Madden**

prepared by

**Applied Psychological Services, Inc.
Science Center
Wayne, Pennsylvania**

for

**Engineering Psychology Programs
Office of Naval Research
Washington, D. C.**

under

Contract N00014-77-C-0448

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED
Decision Aid Evaluation Program Annual Report		Annual <i>rept.</i> Jul 1978 - June 1979
6. AUTHOR(s)		7. CONTRACT OR GRANT NUMBER(s)
Arthur I. Siegel Edward G. Madden		N00014-77-C-0448
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Applied Psychological Services, Inc. 404 E. Lancaster Avenue Wayne, Pennsylvania 19087		
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE
Engineering Psychology Programs Office of Naval Research Arlington, Virginia 22217		June 1979
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES
(12) 15p.		9
		15. SECURITY CLASS. (of this report)
		UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)		
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
Decision Aids System Evaluation Information Systems Evaluative Research Information Management Performance Criteria Man-Computer Interaction Information Processing Interface Design		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
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ABSTRACT

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DECISION AID EVALUATION

Over the past year, the Applied Psychological Services has been engaged in a program to evaluate decision aids, developed by others, under the Office of Naval Research's operational decision aid development program. Specifically, for each member of a set of individual operational decision aids, the purpose of the present program is to answer such questions as:

- Does it work?
- Why does it work?
- How can it be made to work better?

The evaluations are to be conducted in accordance with the following criteria:

- use of well-controlled, precise, multivariate methods
- programmatic approach
- full coordination with ONR
- orientation towards possible conditions of actual aid use in the Navy
- coordination with aid developers but maintenance of evaluation integrity
- use of previous developed action scenarios where possible

This Annual Report--Decision Aid Evaluation Program describes the work performed during the period July 1978 through June 1979. The report is summary in nature because a full technical report describing the details of the major accomplishment over the period, an evaluation of the strike timing decision aid developed by Analytics, Inc., is currently in preparation.

The activities over the year may be subdivided over five areas: (1) evaluation perspective development, (2) coordination with personnel responsible for the development of the operational decision aid laboratory at the Wharton School, University of Pennsylvania, (3) development of a plan for evaluating the strike timing aid developed by Analytics, Inc. and collection of the required evaluative data, (4) report preparation relative to the strike timing aid evaluation, and (5) preparation for an evaluation of the emission control decision aid developed by Decision Science Applications, Inc. The work completed in each of these areas is described categorically below.

Evaluation Perspective Development

Because it seemed important to place the present evaluation program in the context of a total decision aid developmental framework, a conception of the steps to be followed during the development of such aids was developed. Figure 1 presents the conception. The figure is read from bottom to top with

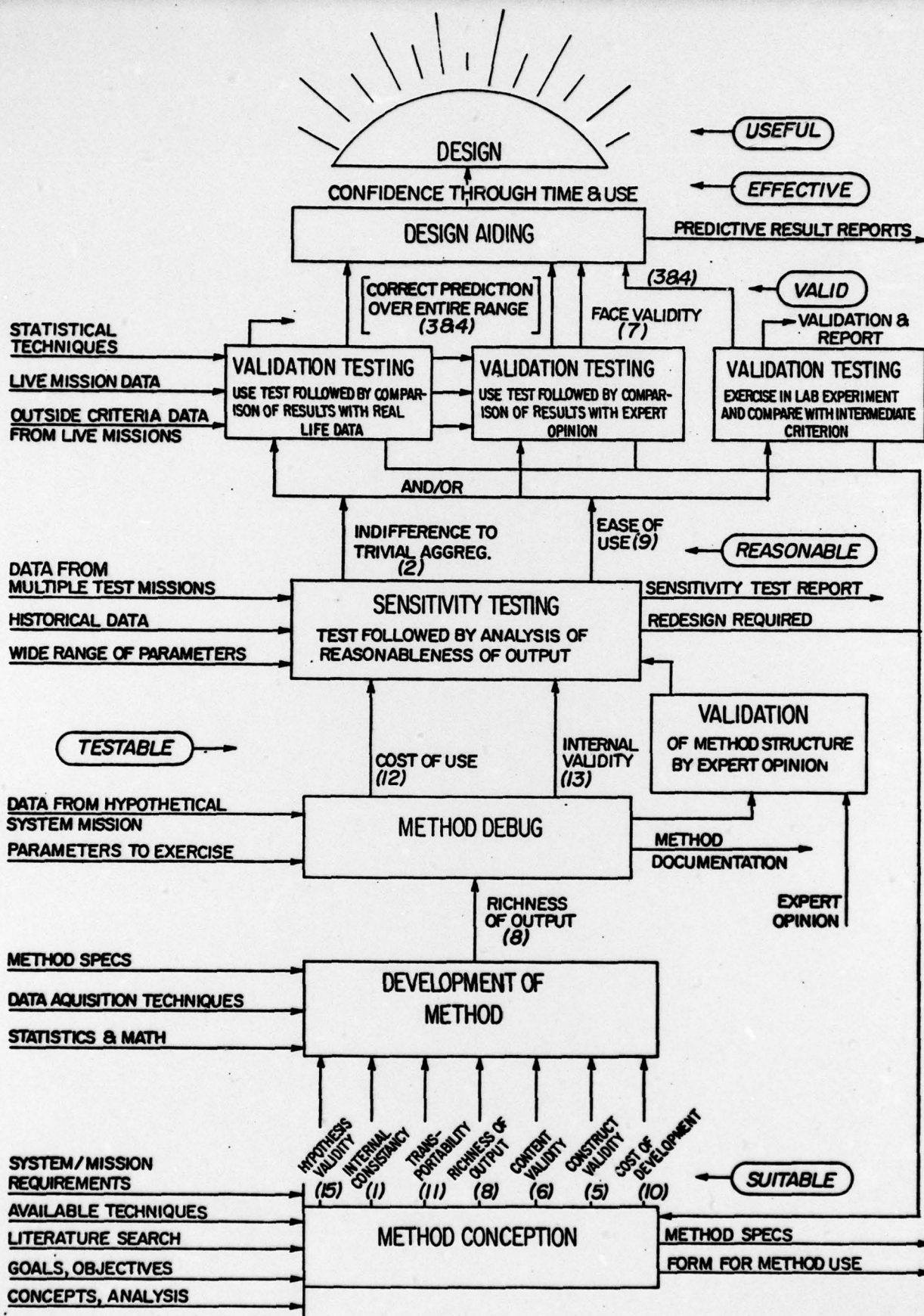


Figure 1. Sequence of aid development.

the considerations involved in each stage entering from the left of each box and the results of each stage exiting to the right. The arrows emerging from the top of each Figure 1 box represent criteria which may be applied after each developmental stage. These criteria are defined in Table 1. The rounded boxes associated with each rectangular, stage box represent descriptors which may be applied as the criteria at the successive stages are met. Accordingly, an aid may be successively called "suitable," "testable," "reasonable," "valid," "effective," and "useful." Note that we are primarily concerned within the present program with the upper right box--"validation testing-exercise in lab experiment and compare with intermediate criterion."

Coordination with Laboratory Site

The data acquisition aspects of the aid evaluations are completed at the decision aid laboratory, established by the Office of Naval Research (ONR), at the Wharton School, University of Pennsylvania. Ongoing coordination was completed with the personnel at the laboratory. Such coordination served to assure that the laboratory's capability was sufficient to support anticipated aid evaluations. To this end, considerable progress was made, in collaboration with Wharton School personnel, towards increasing the reliability of the equipment suite, decreasing access time in the time sharing situation, and organizing an effective data recording and acquisition system. While some problems still remain in each of these areas, considerable progress was made towards minimizing their effects on any emergent evaluative data.

Strike Timing Aid Evaluation

The strike timing aid, developed by Analytics, Inc., was the first aid to be evaluated under the present program. The strike timing aid is a sophisticated, man-computer interactive tool for deriving strike timing decisions. It considers a host of own force readiness, enemy force, and environmental considerations in a probabilistic manner and yields the information necessary for deriving a "preferred" strike launch time.

To evaluate the strike timing aid, an evaluative plan was developed and distributed to all concerned parties (Analytics, Inc., Wharton School, Office of Naval Research). Because there was a wide variety of comments--sometimes conflicting--to the evaluative plan, a coordination meeting was called at which the various concerned organizations were represented. As the result of the coordination meeting, a second plan was written to reflect the various suggested modifications. This second plan was submitted to the concerned organizations with the result that a new set of comments (sometimes conflicting with original remarks) was received. A second coordination meeting resolved the issues and a final plan was written and submitted.

Table 1

Criteria for Evaluating Decision Aids at Various Developmental Stages

<u>Criterion</u>	<u>Definitions</u>
1. Internal consistency	Extent to which the constructs of the aid are marked by coherence and similarity of treatment
2. Indifference to trivial aggregation	Potential of the aid to avoid major changes in output when input groupings or conditions undergo insignificant fluctuations
3. Correct prediction in the extreme (predictive or empirical validity)	Extent of agreement (correctness of predictions) between aid and actual performance at very high/low values of conditions
4. Correct prediction in mid range (predictive or empirical validity)	Like above for middle ranges values of conditions
5. Construct validity	Theoretic adequacy of the aid constructs
6. Content (variable/parameter) validity (fidelity)	Extent to which the aid's variables/parameters match real life conditions
7. Realism or "face validity"	Extent to which selected content matches each attribute modeled
8. Richness of output	Number and type of output variables and forms of presentation
9. Ease of use	Extent to which an analyst can readily prepare data for, apply and extract understandable results from the aid
10. Cost of development	Value of effort to conceive, develop, test, document, and support
11. Transportability - generality	Extent to which different systems, missions, and configurations can be considered
12. Cost of use	Value of all effort involving use of aid including data collection, input, data processing, and analysis of results
13. Internal validity	Extent to which outputs are repeatable without change of inputs
14. Event or time series validity	Extent to which simulation predicts events, event patterns
15. Hypothesis validity	Extent to which model relationships correspond to similar relationships in the observable universe

Then, work started in accordance with the agreed on plan. Because the plan called for comparing the "correctness" of strike timing decisions made under various levels of aid employment, the most preferred answer to a set of stimulus strike timing problems was required. To this end, a panel of Navy officers was organized at the Office of Naval Research. The panel was asked to rank order the members of a set of possible strike launch times for each problem. A modified Delphi technique was employed to collect the information and group convergence was not difficult to achieve. The data collection took place over a 1.5 day period. One interesting artifact of the work was the finding that the panel members themselves often possessed implicit and explicit personal algorithms for solving such problems.

The general evaluative design for the strike timing aid is shown in Figure 2. There are five levels of aid employment (aid variations), two problem difficulty levels, and two levels of operational experience.

To train the evaluation subjects in strike timing aid use, a separate script was written for each condition and a television tape was prepared on the basis of each script. The 50 subjects, required by the design, were recruited locally. The subjects of the little or no operational experience group were recruited from the NROTC group at the University of Pennsylvania while the subjects of the operationally experienced group were persons with recent Navy experience. They held ranks from Lieutenant to Captain on discharge from active duty. All of the latter group possessed flight experience.

Data collection for each subject was completed in a single, four hour session. At the conclusion of the formal data acquisition, an extensive interview was completed with each experimental subject. The interview inquired into perception of the utility of the aid, areas for aid improvement, features in the aid which might be modified, subjective confidence in answers and the like.

A number of formal analyses of the data was also completed. The results of a set of variance analyses indicated support for the aid. A multi-attribute utility analysis also yielded results which support the aid.

Report Preparation

A full technical report describing the methods, procedures, and results of the evaluation of the strike timing aid was partially prepared. However, completion of the report was postponed so that the research team could focus its attention on the second aid to be evaluated, the emission control aid by Decision Science Applications, Inc.

Evaluation of the Emission Control Aid

The purpose of the emission control aid is to help in the derivation of an electronic emission complement which will maximize the surveillance

Treatment		<u>Experienced</u>		<u>Inexperienced</u>	
		<u>Hard</u>	<u>Easy</u>	<u>Hard</u>	<u>Easy</u>
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	s1	-	-	s26	-
	.	-	-	-	-

		-	-	-	-
	s5	-	-	s30	-
		-	-	-	-
		-	-	-	-
2		-	-	-	-
	s6	-	-	s31	-
	.	-	-	-	-

		-	-	-	-
	s10	-	-	s35	-
		-	-	-	-
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(unaided)					

Figure 2. Evaluative paradigm for strike timing aid.

effectiveness of a task force while minimizing the amount of information about the task force which is made available to the enemy. Like the strike timing aid, the emission control aid is man-computer interactive and is based on extensive sets of optimization algorithms.

Each aid evaluation seems to possess special problems which do not become evidenced on initial exposures to the aid or initial sets of interactions with the aid's developers. In the case of the emission control aid, there were two such problems: (1) the full utility of the aid may not be assessable unless the user's are provided with hard copy of their various emission control conjectures about each problem, and (2) the full utility of the aid cannot be assessed unless the users have considerable training related to a set of heuristic rules (believed by the aid developer to be important to emission control) for proper emission control.

The first of these problems was managed by adding a Tektronix 4013 with a hard copy unit to the research equipment. The second problem, heuristic training, was managed by building an extensive training period into the aid evaluation.

The general design for the emission control aid evaluation is shown in Figure 3. This design was derived as the result of a preliminary design developed by Applied Psychological Services and a set of coordination meetings involving Applied Psychological Services, Decision Science Applications, Wharton School, and Office of Naval Research personnel. The full design was contained in a formal report submitted on 8 June 1979.

By the conclusion of the period reviewed in this Annual Report, the laboratory preparation aspects (problem insertion and test, problem correction, programming, and equipment organization) were about 75 per cent completed. As is not unusual, considerable computer program reorganization/correction was necessary. The training program was detailed and arrangements for subjects were partially completed. According to current plans, as many subjects as possible will be drawn from instructor and staff personnel, with operations experience, at the U.S. Naval Academy. The training will be administered at the Academy while the formal evaluative data acquisition will take place at the decision aid laboratory at the Wharton School. Additional subjects will be recruited and trained locally, if necessary. According to current plans, the training for the Academy will take place during the week of 9 July and data acquisition will start immediately after the 1.5 day training period is completed.

Group	Training	Aid Levels	Difficulty
Experimental	Heuristics Included	Full Aid	Easy
			Hard
		No Aid	Easy
			Hard
Control	No Heuristics	Full Aid	Easy
			Hard
		No Aid	Easy
			Hard

Figure 3. Design for the EWAR decision aid evaluation.

Reports

Over the period, two design reports were prepared:

Applied Psychological Services. Evaluative design for EWAR decision aid. Wayne, Pa.: Applied Psychological Services, 1979.

Siegel, A.I. An experimental design for evaluating the "strike timing aid." Wayne, Pa.: Applied Psychological Services, 1978.

Personnel assigned, over the period, to the work were: Dr. A. I. Siegel (Principal Investigator) and Dr. E. Madden (Research Associate).

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